DESIGNING EPISTEMOLOGICALLY CORRECT SCIENCE NARRATIVES

By

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ABSTRACT

In recent years use of narratives for teaching science at secondary school level has gained impetus. This paper deals with the problem of designing narratives for teaching scientific concept. The central issue of the problem of designing narratives for carrying scientific information is that science belongs to the domain of objective observation of facts and general principles while narratives belong to the world of humans and their aspirations which are subjective in nature. If a narrative of science is built purely on intuitive bases, without any structural foundation, the epistemic correctness of the narrative may be doubted. This paper presents what is known as the Epistemic Narrative Structure (ENS) which synthesis principles of Narrative structure with general structure of a scientific discovery event. It is proposed that if a narrative about teaching science is built on the epistemic narrative structure, then the problem of synthesizing subjective human context and objective nature of scientific reasoning can be resolved leading to design of epistemologically correct science narratives. In this paper, the Epistemic Narrative Structure is explained and how it can be used to design a science narrative with an example of writing a narrative on 'how electric battery came into being.The narrative structure is replicable and can be used by teachers to design their own epistemologically correct science narratives.

Keywords: Narratives, Science Education, Knowledge, Epistemology

INTRODUCTION

This paper exists in response to an overflow of narrative based instruction material being produced in India to teach science at secondary school level. Narrative as a medium of communicating educational information is being widely studied and used for educational purposes. This could largely be due to the rising number of research publications in this area. Narratives have been related to primordial human expression and making sense of the world.

> Egan makes the case that stories form a natural vehicle and means of educating students not only about their cultural and historical roots but also the scientific descriptions of reality (Lucy Avraamidou, 2008).

Worth establishes the relationship between Narratives and humans' way of making sense of the world and their experience of the world:

> Story telling is one of our primary forms of communication with other people. Narrativity is the principle way that human beings order their experience in time. It is also one of the primary ways that humans make coherent sense out of seemingly unrelated sequences of events. Thus, an account of how this ordering works is essential to understanding one of the many ways of knowing used by humans (Worth, 2008).

Without going further into finding whether the belief that unites narratives and its educational potential is valid or not, we move straight to the problem of teaching science with the narrative approach (assuming, based upon literature evidence that humans do in fact, best understand the world in Narrative format).

The problem of teaching science using narratives is qualitatively different from using narratives for educational purpose in general. This is because 'Science' is a distinct human enterprise, separate from many other type of educational activities that humans undertake. A person or student may be required to remember some names (in

geography or chemistry or Biology). They may be required to solve mathematical problems. In other scenario, someone may learn how to operate a machine. Then there are educational practices related to development of moral and ethical values. Students may be required to remember events associated with some historical moments that shaped the history of human civilization. All these activities a person can do without evoking any principle of science. As it was said earlier, Science as an enterprise or activity requires the human agents to act in a specific way or method. Hudson has stressed on the need to present the nature of science to students and teachers in a world where the closest sources of information available to general public about science is newspapers and television and internet which may not provide them the critical methods of inquiry that a culture of science has its foundations in. According to Hudson:

> *The construction and appraisal of argument is a crucial dimension of scientific practice. Consequently, understanding the nature of scientific arguments and being able to construct and evaluate them is a crucial element of scientific literacy. Thus, we need to provide frequent and rich opportunities for students to explore and use the language of science: to read and write science, discuss the meaning of scientific text, note how ideas are supported by evidence, construct plausible arguments and evaluate arguments constructed by others. Because most people obtain the bulk of their knowledge of contemporary science and technology from television, newspapers, magazines and the Internet, the capacity for active critical engagement with scientific text is a crucial element of scientific literacy (Hodson, 2009).*

If a Narrative on science is to be built, it will do justice only when it encompasses within it the specific actions that agents in a scientific enterprise do.

In order to find the relation between Narrative structure and scientific inquiry event, a search into literature on Theory of Knowledge, Theory of Learning and Theory of Narratives was commenced. The final outcome of the search was the development of the Epistemological Narrative Framework. This framework is meant to assist content developers in designing science lessons in a Narrative format by having a better understanding of the scientific process of a discovery event and also help them check epistemic correctness of a science narrative.

Proposition

One of the ways by which process of scientific inquiry can be inculcated in science curriculum is by tracing the history of a scientific concept. Allchin believes that historical events of a scientific discovery help in organizing the serial development of concepts and reconstruct reasoning (Allchin, 2000).

An inquiry into the work of John Dewey revealed that Science is a narrative process with certain discrete events distributed in the five step general narrative structure defined by Existing Situation, Doubt, Reasoning, Suggestion, and Situation resolution. It was realized through further search into Theory of Knowledge, that the components given above are linked with some other components associated with a scientific Inquiry.

The basic five steps in Narrative schema of science have further divisions and the overall components of a scientific inquiry process are believed to have the following constituents (Figure 1).

It is suggested, that a science narrative essentially need to have these components. Absence of any one of these will lead to communicating false or incorrect process of science to the audience of the narrative. The reason for believing that process of scientific inquiry has the components presented in Figure 1 is given in the following manner.

The first point of justification is supported from John Dewey's explanation of the Narrative Nature of a scientific inquiry event. The narrative schema presented in Figure 2 is an extension of the Narrative process of a scientific inquiry presented by John Dewey. Dewey's schema of a scientific inquiry is given in Figure 3.

John Dewey went as far as to believe that the 'reality' itself which philosophers and scientist have been attempting to understand (since birth of cognitive abilities in the human mind in prehistoric ages), is essentially Narrative in Nature.

Dewey believed that something appearing as permanent and rigid as a mountain, in a geologist's reality, is a scene of a drama of birth, decay and ultimate death. A flash of lightening to a layman may appear as a single event but for a scientist has a prolonged narrative history, with the growth of science, the tale of why lightening happens, becomes longer(Dewey,1955, p. 222). The 5 step process of scientific inquiry event proposed by Dewey aligns well with Freytag's Pyramid which has basic components of Exposition, Rising action, Conflict, Falling action and Deneoument (Figure 4).

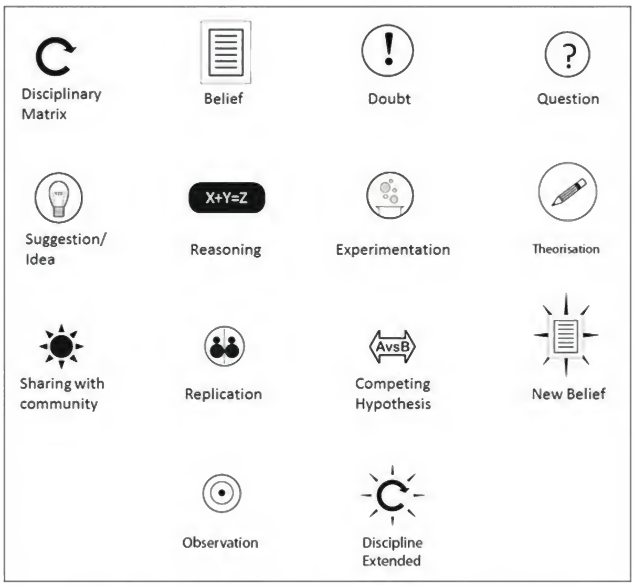

Figure 1. Components of a scientific inquiry event in context of a scientific community

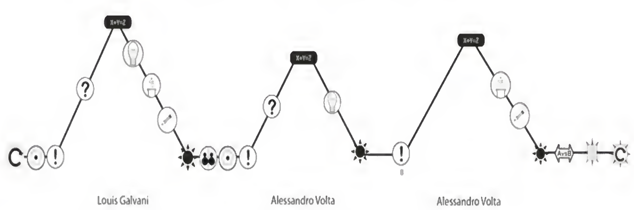

Figure 2. Symbolic representation of Story of Voltaic cell

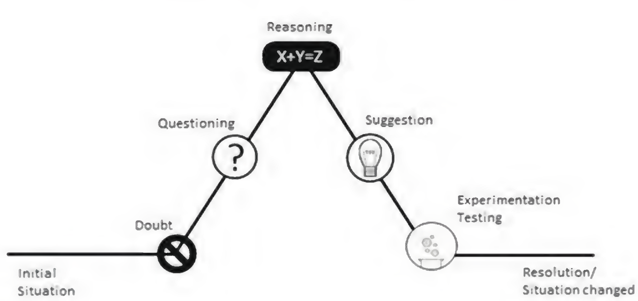

Figure 3. John Dewey's narrative process of a scientific inquiry (Dewey, 1955, p.105)

The second justification for believing in the truth of Epistemological Narrative Framework presented in Figure 1 come from the picture of a scientific community painted by Thomas Kuhn in his papers on 'The Structure of Scientific Revolutions'. Kuhn explained that the compilation of a theory is not one person's work. Development of scientific ideas is directly related to the organization of the scientific community as a whole with its tradition of common language for knowledge sharing among members of a community within the context of a particular paradigm or disciplinary matrix (Kuhn, 1962). This is where Arthur Stinner's concept of a Large Context Problem also comes into the picture. The progress of science begins with putting down of some general principle regarding a particular phenomenon of nature by some philosopher or scientist. This General Principle may be completely wrong or a misunderstanding. A different alternative is provided by another protagonist with different set of justification. This process goes on and on till there is a sufficient consensus among the scientific community members. Arthur Stinner explains with the help of example from history of atomic structure. Instead of explaining a concept, say of atomic structure by giving details of what we know today about atoms, we should explain the evolutionary process by which the idea of Atomic structure has changed over the centuries starting from Democritus to Dalton, Rutherford, Thomson and Neil Bohr(Stinner, 1995). The role of a closed community is as important as the process of acquiring knowledge by a scientist in the development of scientific theories.

The two ideas of the role of individual research and the role of a social community in advancement of science can be seen from another point of view which is presented in literature on Theory of Learning. Piaget's Constructivist

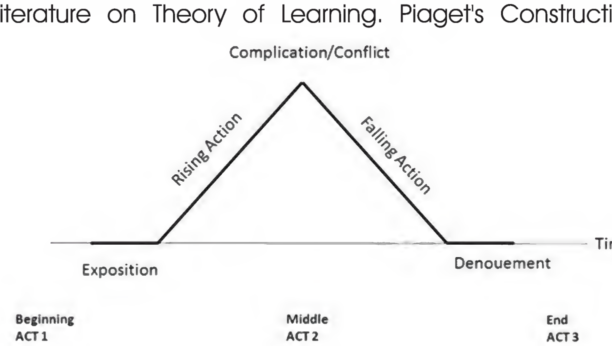

Figure 4. Freytag's plot structureof Drama

theory of learning can be compared with an individual's process of acquiring knowledge in the four step process of Existing Schema (Assimilation), Expectation breaking event, Adjustment of new information into existing schema through Accommodation and the establishment of New Schema (Leonard, 2002). However, constructivist theory is limited to an individual's learning process. This limitation is rectified in Vygotsky's theory of social constructivism where learning is also a function of the socio-cultural environment in which the student learns, which not only includes the teacher but, friends and family background (Ivic, 1994). For these reasons, the cultural aspect of science and its routine ways of sharing knowledge through community presentations and publications are part of the Epistemological Narrative structure.

Justification

One might ask the justification for the need of explaining the story of evolution or a theory or concept to present generation students? Deanna Kuhn asserts that the very notion of scientific understanding consists of succession of incorrect theories that gradually are replaced with correct notions as more information becomes available about the phenomenon under study and it is important for science educators to be acquainted with this process (Deanna Kuhn, 1988, p. 13).

In the following section, each component of a scientific inquiry event is briefly explained with reference to relevant literature.

- Disciplinary Matrix (Paradigm) C

Each domain of study whether Astronomy, Mechanics or Optics has certain routine activities that are required to be performed by its practitioners. These practices themselves undergo a transformation over centuries. But at each given time or era or age, the practices are routine and repetitive. The practice is standard problems and their standard solutions in a given domain. These standard problem-solutions set which every newcomer in that domain is expected to work upon are known as exemplars (Kuhn, 1977). There is a common element that integrates the various activities of practitioners in a given domain. The element is known as, 'Belief'.

- Belief

According to classical understanding of philosophy, when a belief is justified and held to be true, it qualifies as knowledge. Supporting this is the following statement by Sosa which explains Plato's position on defining knowledge:

A person S believes that p if and only if p is true and S is justified in believing that p is true (Sosa, 1991). A belief is essentially a presumed relation between two or more entities, terms or concepts. The meaning of belief becomes clear from Bertrand Russell's explanation that the relation involved in Judging or Believing must be taken to be a relation between several terms (Russell, 1973). Ram saved Rahim is a dyadic relation and Ram saved Rahim from an accident is a triadic relation. But a relation described in a single event does not constitute a belief.

A belief is a statement describing a relation, but the relation is law like which means that it is a general principle that has occurred in many instances. A single event showing relation between terms is called a 'Fact'. A belief is formed after observation of many facts (Carnap, 1995). Sun rises in the East is a belief. The terms, 'Sun' and 'East' are connected by the term 'Rising'. 'On Sunday, Sun rose in the east' is a fact because it is describing a single event. A fact comes to picture when a single event is observed.

- Observation

Observation is the action of beholding the relation that may exist between two or more entities. For example 'there is winter' and 'there is sensation of coldness' is an observation that leads to the fact that 'it is winter' and 'I am feeling cold'. A fact can simply be 'I am feeling cold' or 'it is winter'. Observations are stepping stone towards experiencing a fact. Observation does not by itself involve reasoning (Watts, 1833, p. 51). It is only a single experience of finding relationship between two or more terms present then and there before an observer. That 'humans feel cold in winter' is a belief which is established after many instances of observation of singular facts' that it is winter and I am feeling cold'.

Beliefs can be mistaken. They may be misconception or false assumptions based upon some error of judgment. In that situation a belief is doubted.

[1]From Boyle's law explained by Carnap (Carnap, 1995, p. 47)

- Doubt

The death blow to a belief can be placed by a 'single fact' which falsifies the belief. If a fact is observed that on Tuesday 20 January 2008, 'sun rose in the west', then the belief that sun rises in the east is falsified. A belief contrary fact is a 'doubtful' fact. The belief is so strong that the fact itself is doubted, not the belief.

> *In cases of striking novelty or unusual perplexity, the difficulty, however, is likely to present itself at first as a shock, as emotional disturbance, as a more or less vague feeling of the unexpected, of something queer, strange, funny or disconcerting (Dewey, How we think, 1910).*

That which violates expectation is also called by the name 'anomaly' by Thomas Kuhn. Kuhn Explains:

> *Discovery commences with the awareness of an anomaly, i.e. with the recognition that nature has somehow violated the paradigm-induced expectations that govern normal science(Kuhn T. S., The structure of Scientific Revolutions, 1962).*

The method of systematic doubt was introduced by Descartes as a sure way of arriving at knowledge with absolute certainty. Descartes thought that valid, justified knowledge can only be arrived when the truth of each and everything that one believes is doubted (Harris, Fundamentals of Philosophy; Study of Classical Texts, 1968). If in that process of doubting everything, one arrives at a statement of belief that however one tries cannot doubt, than one can be sure that belief is justified and true Knowledge. If a doubt is systematically pursued, it leads to a specific question asked to put light on a matter that is unknown.

- Questioning

A well-formed question is the beginning of an inquiry. It is recognition of the fact that something is unknown. It is the very nature of an unknown situation that calls for an inquiry (Dewey, 1938, pp.105). A doubt is a 'fact' that contradicts established 'belief'. A question that is clear, also has with it a justification for asking it. For example let us consider on a particular day, Sun rose in the West. People might question, 'Why is Sun rising in west? They are justified in asking this because it is a general belief that 'Sun rises in the East'. Why am I feeling cold in room temperature? Because of the general belief that a healthy person does not feel cold in room temperature. A question provides an opportunity to look into some underlying general belief.

- Reasoning

In order to find an answer to the question, tool of reasoning is employed. Reasoning can be Deductive or Inductive (Dewey, Logic: The Theory of Inquiry, 1955). If some relation associated with a particular event is to be found like from General Principles, then deduction is applied. If a general rule, law or theory is to be formulated from particular instances, Induction is applied. Deductive inferences look for certainty while Inductive conclusions are only probable; they are true only to a degree. These two categories of reasoning points to two different set of problems; the problem of assigning or identifying properties or relations of a single object or event and the problem of identifying a general rule behind occurrence of a series of events or objects respectively.

Deduction and Induction can give rise to tow different kind of dialogues if we suppose that every Argument follows from a question. For example, consider the argument:

- All Planets are spherical
- Pluto is a Planet
- Therefore Pluto is spherical

This argument follows from the question "What is the Property of Pluto". The conclusion of the Argument (That Pluto is spherical) is answer to the question. The dialogue then has three parts; Question, Reasoning and Answer. A deductive dialogue is mostly used for identification of a particular unknown entity or event. Then we move on to know something X that we know about the entity and something Y that we know about X. For example:

Teacher: State one property of Pluto?

Student (Reasoning): We know that Pluto is a planet

We also know that all Planets are spherical

Student(Answer): Pluto is Spherical Similarly, Inductive form of dialogue can follow similar line of thought but based upon Inductive form of argument.

Although, a conclusion or answer is natural fallout of reasoning process, the answer is only a suggestion. It is still only a belief.

- **Suggestion**

The final solution or as Dewey calls it, suggestion is arrived at by matching a new situation with already known objects, events or beliefs in the observer's memory. The mind of the observer depends upon existing data to reflect upon and present any new insight or answer (Schank, 1990). It is primarily an act of synthesizing many facts to form a conclusion.

- **Experimentation**

Experimentation is nothing but the extension of reasoning, but with a difference. In the reasoning process, the observing agent is not manipulating the phenomenon. He/she waits for the phenomenon to occur naturally. In experimentation, deliberate attempt is made to change the conditions and observe what happens when some change is introduced (Carnap, 1995). Experiment also has a reasoning process and dialogue involved, but it is more Inductive in nature than deductive and it involves setting up of certain conditions in which the various factors influencing a phenomenon can be observed.

Consider the following Inductive dialogue regarding an experiment on air pressure:

Teacher: What is the general Principle pertaining to relationship between Pressure and Volume of a gas in a closed vessel?

Student (Reasoning): It was observed in 'n' number of cases that when pressure was increased, volume of gas decreased when temperature remained constant. And when pressure was decreased, the volume increased at constant temperature.

Student (Answer) : Therefore, I think that in a closed vessel if temperature is kept constant, the Volume of gas in it increases if its pressure decreases and the volume decreases if the pressure increases.

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The experimental method for strengthening the earlier reasoning and remove any possible doubt in previous inference and arrive at greater certainty by helping in formulation of quantitative laws or theories. It may also help in isolating exceptions and finding their cause.

- **Theorization**

Experimentation presents a database of new facts. These facts are then put together again by Induction and Deduction to form a new belief. The new belief is an alternate proposal showing relation between two or more terms. The more facts are presented with experimentation, more strong the theory becomes (S.E.Smith, 2011) and it moves from being merely a belief to being 'valid Knowledge.'

- **Sharing with the community**

In order to strengthen or refute the claim of knowledge

made by a single individual, the scientific community has developed a systematic way of sharing knowledge among its members through public conference and publication of papers. The community also has a common language so that each member can understand and share a common meaning (Kuhn, 1977, pp. 296). A shared meaning is indispensable for another member to critique, either accept or modify or propose an alternative in the existing theory.

- Replication 

In order to verify a scientist's claim to knowledge, it needs to be verified by other members of community. Other members verify it by replicating the experiments that the original theorists propose. along with all the necessary and sufficient conditions The replicated experiments can either reveal some unexpected fact in the process which the original researcher missed, in that case the new researcher modifies the experiments and with a new reasoning present an alternate theory or knowledge claim.

- Competition/Comparison 

The replication process of many researchers may either produce same results or contradictory results. Due to different result, if pursued further many researchers may propose alternate theories to explain observations made on the same phenomenon. The final responsibility of choosing a theory with best explanation lies in the hands of the scientific council of a particular scientific community. Scientific councils may have relative criteria for selection, accuracy in one case, scope in another (Kuhn, 1977, pp.322). According to Feyrabend the development of a theory may not be based upon any rational or empiricist criteria, other factors like Aesthetics, personal whims and society may play a major decisive role in the final judgment(Feyerabend, 1975). This aspect is unique to each discovery event and may not be captured in any structure.

These are the main reasons for believing that a scientific inquiry event in the context of the scientific community with a defined tradition has the structure of a Narrative presented in Figure 2. The letters A and B used in Figure 2 represent the protagonists A and B exploring the same phenomenon. The arrangement of how these elements are related is given in figure 2. All scientific inquiry events may not follow the exact sequential pattern presented in ENF. Each Inquiry event is unique and may have a different sequence of events, but the basic elements remain the same.

- New Belief and Discipline Extension

Once the new theory is established, It leads to formation of new belief regarding relation between concepts and that in turn extends the discipline or domain of knowledge. For example, the work of Alessandro Volta replaced the existing belief of animal electricity proposed by Galvani with new belief of 'contact electricity' and the subsequent invention of Voltaic cell extended the discipline of electricity further.

In the next section we see how these elements are present in the story of Voltaic cell, (Table 1).

Volta and the Voltaic Cell

Act I: Long times ago in Italy, people suffering from muscle spasm were treated with the help of a device called the Leyden Jar. A doctor by the name of Galvani was famous for using Leyden Jar for treating such patients. Galvani was also an anatomist and often experimented with dissected frogs. One day while experimenting to test the effect of electric charge on Frogs, a strange thing happened. As soon as he touched the frog's leg with a metal knife and simultaneously touched a Leyden jar, the frog's leg started twitching even though there was no visible contact between the frog and the Leyden jar. Galvani tried with many different metals and in all cases there was a twitching in the frog's leg.

Act II: Galvani after some contemplation came to the conclusion that there was some form of electricity possessed by the frog. He immediately made an announcement in Italy's scientific society, of having discovered a new form of electricity called animal electricity. There was another scientist in the crowd, Volta. He decided to replicate the experiment in his lab. He found out that the frog's leg only twitched when it was touched by dissimilar metals and it did not twitch when the metals were same. He immediately made an announcement that the leg twitched because of metal and not because of animal electricity. But Galvani showed that leg twitched even when touched by finger. Volta returned home and this time tried

	The Voltaic Cell
	In eighteenth century Italy, lived a physician whose name was Galvani. He routinely used the Leyden Jar to treat patients who suffered from muscle spasms. Leyden Jar was a static electric charge storage device. Galvani was also studying the effect of electric charge on animal tissue for which he experimented with frogs.
	In one such experiment when Galvani was testing the effect of electric charge on frog, a strange thing happened. As soon as he touched the frog with a metal knife, its leg started twitching.
	Galvani wondered caused the dead frog's leg to twitch?
X+Y=Z	Since Static electricity is associated with magnetic properties as well, Galvani inferred that the frog's leg moved because it was connected to Leyden jar. Galvani removed the Leyden jar to see what happened. The leg still twitched. Galvani Recalled that electric eel gave electric shock when touched. Galvani inferred that maybe charge was produced inside the animal body.
	From this experiment Galvani proposed that there was another form of electricity that was distinct from static electricity. He called it the 'Animal Electricity' which is generated inside the body of animals.
	He went to the scientific council of Italy and shared his discovery with them. His theory was readily accepted.
	However, there was another scientist in Italy called Volta who decided to Replicate Galvani's experiment.
	Volta noticed that leg of frog did not twitch in all conditions. It twitched only when leg was touched by a metal different from the metal dish in which the frog was kept. He wondered why this was happening.
X+Y=Z	Since twitching of Frog's leg was dependent upon combination of metal used in plate and knife, Volta inferred that the twitching of frog's leg must be due to difference of metals rather than animal electricity.
	Volta shared his hypothesis with the Community. But…
	Galvani showed that the frog's leg twitch with his finger as well when no metal was touched at all. Galvani's theory was still strongly believed
X+Y=Z	Volta was still not convinced.He thought if the leg twitching was due to metals used, then the current should be present even when frog was absent. He did another experiment by removing the frog altogether from the experiment. He made an apparatus resembling the copper dish, Saline solution and Zinc knife setup. The apparatus was a zinc and copper strip dipped in saline solution. When he connected the zinc and copper electrodes, it showed deflection of aluminum foil in the electroscope, confirming the presence of current.
	Volta proposed that the twitching of frog's leg was due to a different type of electricity called 'Contact electricity' which gets generated when certain metals come in contact with certain chemicals. He confirmed his theory by making a real apparatus called the Voltaic cell.
	When Volta shared the idea of contact electricity, there was resistance from accepting it but when he demonstrated with the help of the Voltaic cell, it became clear that the idea of Animal electricity was wrong.
AvsB	This established a new belief that electricity could be generated with the help of an electrochemical reaction and the foundation of a new branch of chemistry called Electrochemistry came into being.
	People started making Voltaic cell as it was very easy to make and the first source of continuous electric supply, came into being. Later many other scientists did experiments to improve the efficiency of the cell in the process many different varieties of batteries got invented

Table 1. Constituents of ENF in discovery event related to story of Voltaic cell

to see if there was any effect when the frog itself was removed. He found that when he connected the metal and plate with wire, it showed a deflection in Electroscope. This confirmed that the current was in the metal knife and not in the frog. Volta made an apparatus to demonstrate this phenomenon.

Act III: Volta made an announcement again in the scientific society. He showed the apparatus and called it the Voltaic cell. He connected many voltaic cells together to create charge enough that gave an electric spark. This apparatus, Volta showed to prove that there is another form of electricity called 'Contact Electricity' and that Galvani's claim of animal electricity was false. The crowed hailed Volta for showing them the truth about Electricity. Soon everyone started making their own Voltaic cells. This invention inspired many other philosophers to experiment and create better charge storage devices which were later used to run lighting equipment and many other things and that's how Volta's invention changed the world. But Volta's notion of contact electricity too was false. Later it was found out that the current flow was because of a chemical reaction and not simply contact between metals. The story was symbolically represented in Figure 2.

Recommendation and Implications

The most important implication of the ENS approach is that is provides a realistic perception of a scientific enterprise and its practice. It is believed that general perception of science is that it is free of errors and it is about moving from error to truth, while this is not the case in reality. Allchin has clearly explained this point in the following statement:

The public concept of science is monolithic. Science is the ultimate authority. It is error-free. Hence, errors are "blunders". They are either an embarrassment or a source for ridicule.

Ultimately, I claim, "fixing" error is about understanding or fully characterizing the error. That is, error is not some residual "leftover" of successful truth-seeking. Rather, error is one product of science. It is a form of knowledge. And it is important in guiding further research (Allchin, 2000).

If a narrative is built keeping in mind elements of ENS, the notion of errors being a part of science as suggested by Allchin gets clearly communicated.

Another implication of ENS is that it provides clues for checking the epistemological correctness of a science narrative written by a content writer who may be from a nonscientific background or any writer who may have overlooked the epistemological aspect of a scientific discovery event.

One more implication of ENS is that it helps in providing a logical arrangement of concepts from simple to complex and places them in a context of origin. By tracing the roots of a discovery one finds out the real cause of existence of a scientific concept. For example, the reason why the conventional direction of flow of current is taken to be from Positive to Negative instead of real flow of current from Negative to Positive can only be known by tracing how the notion of (+) and (–) charge was discovered/invented by Benjamin Franklin.

There are many cases in the history of science that present interesting paradoxes to ponder upon which automatically incites inquiry. Such instances may be completely overlooked if historical narrative of evolution of science is not taken into consideration. For example Stephen Grey observed that substances that are electric like AmberGlass or sealing wax are incapable of conducting electricity while substances (metals) that are good at conducting electricity, are incapable of producing it by friction. This is more than simply explaining what a conductor and insulator is which the current textbooks limit themselves to. The contradictory nature of electric generation and flow can only be accessed if one follows the original experiments and thought process of the scientist. t is true that the actual process of how a concept was created by a scientist can be very lengthy and complex, but it is possible to simplify the narrative keeping the key discovery element present in the ENS in mind.

It is believed that teaching the process of a scientific inquiry event is more important than teaching volumes of concepts which are only the final outcome of the scientific process. Epistemological Narrative Structure is an attempt to enable science educators in achieving this goal.

Based upon the arguments presented above, it is suggested that learning the process of science if is

considered essential for science content developers and further if science is to be taught with the help of a narrative format, then the elements of a scientific narrative present in the Epistemological Narrative Structure will help the content developers in understanding the process of science and develop narrative informed by the practices of scientific culture. There may be many more complexities of scientific culture and its manner of operation and the ones presented here may be just a fraction of it. The Epistemological Narrative Structure may provide a sort of decision making support while choosing significant events to be included while designing a narrative for explaining a science concept.

Conclusion

The narrative framework presented here is not meant to assist in writing science narratives. Story writing requires different set of skills and abilities. However when the story is written, the epistemic narrative structure can be used to check the validity of the narrative. A correct science narrative will present a step by step process of justifying why a certain theory is better than the other. A general narrative which does not consider the epistemic aspect of science may overlook this important point. Drawing example from logic to explain this point further, just as logic does not make a person a better writer, it only helps check whether the arguments in a particular piece of writing is sound, so also the Epistemic narrative structure may not help someone become a science writer, but it can be used to check the soundness of historical narrative argument and justification present in the narrative.

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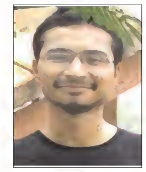

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